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Certified by

Jon W Dudas

Acting Under Secretary of Commerce
for Intellectual Property
and Acting Director of the U.S.
Patent and Trademark Office

U.S. PATENT AND TRADEMARK OFFICE
PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 C.F.R. §1.53(b)(2)

Atty. Docket: GIL3.1

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[ ] Additional inventors are being named on separately numbered sheets attached hereto

TITLE OF THE INVENTION (280 characters max)

AN ILLUMINATION METHOD AND SYSTEM FOR OBTAINING COLOR IMAGES BY TRANSCLERAL OPHTHALMIC ILLUMINATION

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ENCLOSED APPLICATION PARTS (check all that apply)

[X] Specification (with Figures 1-5 incorporated within the specification) Number of Pages 18

[X] Applicant claims small entity status. See 37 C.F.R. §1.27

[ ] Other (specify) ______

METHOD OF PAYMENT (check one)

[X] Credit Card Payment Form PTO-2038 is enclosed to cover the Provisional filing fee of

[ ]$160 large entity [X] $80 small entity

[X] The Commissioner is hereby authorized to charge filing fees and credit Deposit Account Number 02-4035

The invention was made by an agency of the United Stated Government or under a contract with an agency of the United States Government.

[X] No [ ] Yes, the name of the U.S. Government agency and the Government contract number are:

______

Respectfully submitted,

BROWDY AND NEIMARK, P.L.L.C.

Date: July 3, 2003

By: ______
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An illumination method and system for obtaining color images by transcleral ophthalmic illumination

Abstract

Disclosed are improvements in an illumination system for fundus imaging systems of the type employing transcleral illumination of the interior of the eye. More precisely, it is an improvement in the method of obtaining color images of the fundus as described by US Patent nr. 6309070 (Svetliza, *et al.*). Color images of the interior of the eye are obtained by illuminating the sclera through red-yellow-green (RYG) filter wheel and obtaining three corresponding grey-level-coded images of the fundus. Those images are then treated as red-green-blue (RGB) images by a post processing unit, which combines them to give a color image. Specifically, the red component of the color image is given by the red-illuminated image required, the green component by the yellow-illuminated image, and the blue component by the green-illuminated image.

This invention is useful for observing or imaging the interior of the eye, the retina, or, the choroid. The observation or the imaging of the interior of the eye, the retina, or, the choroid by applying the disclosed illumination method needs to be done in conjunction with any system that includes optics for that purpose.

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Claims

What is claimed is:

1. A method for integrated ophthalmic illumination comprising the steps of;

providing a light source producing a light beam;

separating red, yellow and green components of said light beam;

sequentially illuminating the eye region with said separated red, yellow, and green components at a rate of one component per frame;

imaging said sequentially illuminated subject; and

processing said sequential color images such that said separated red, yellow, and green components are treated as red, green, and blue components, respectively, and combined so as to obtain a high resolution color image.

2. A method according to claim 1 in which the lamp source is composed of three or more smaller light sources that provide light in three different colors, red, yellow and green, sparing the need of separating the light into these colors.

3. An integrated ophthalmic illumination system comprising:

a light source, said light source being a lamp;

collimating optics, to provide a collimated light beam from the light source;

a wide-band filter (hot mirror) for selecting only the wavelength range that is required for imaging avoiding unnecessary irradiation of the eye;

a separation unit for separating red, yellow, and green components of said collimated light beam, so as to produce sequential color images;

a computer processor; and

an electronic image capturing sensor,

said computer processor taking said sequential color images obtained using the light sources and forming therefrom at least one of high resolution color and monochromatic image.

4. The illumination system of claim 3 wherein said lamp is one of the group of: filament, gas, laser, diodes.

5. The illumination system of claim 3 further comprising electronically-controlled means of controlling the intensity of the radiated light, e.g., taken from a group of fast liquid crystal shutters, for controlling the amount of light from said collimated light beam.

6. The illumination system of claim 5 wherein the said output of the said image capturing sensor is being processed by said processor, said processor controlling said shutter for each acquired frame accordingly.

7. The illumination system of claim 3 wherein said separation unit for separating red, yellow, and green components of said collimated light beam is provided as a filter wheel.

8. The illumination system of claim 7 wherein said filter wheel rotates at a speed of one-third of the frame rate of said imaging means.

9. The illumination system of claim 5 with a method and mechanism of allowing light through only part of the (red, yellow, and green) group of filters, say only one or two filters, during image alignment and focus in order to reduce the amount of light shined on eye, while enhancing for focus a chosen retinal layer by choosing the appropriate illumination band, red, yellow, or green.

10. Claim 9 in which the images acquired during selected illumination are displayed as grey-level black and white images during alignment and focusing in order to improve visual contrast.

11. The illumination system of claim 3 further comprising a neutral density filter.

12. The illumination system of claim 3 further comprising a high-pass filter to transmit near-infra-red (NIR) from the light source.

13. The illumination system of claim 3 further comprising a low-pass filter that in synchronization with a high-pass red segment of the RYG filter wheel yields a band-pass near-infra-red (NIR) illumination.

14. The illumination system of claim 13 with a mechanism of fast exchanging the low-pass with the band-pass filter while switching from NIR imaging to color imaging.

15. A method according to claims 13 of performing focus and alignment under NIR illumination, reducing eye tendency to close its pupil, and fast switching according to claim 11 to color image acquisition according to claims 1,2, 3, and 6.

16. The illumination system of claim 3 further comprising a condensing lens to minimize said collimated light beam.

17. The illumination system of claim 3 wherein said electronic imaging sensor is monochrome.

18. The illumination system of claim 3 wherein said electronic

imaging sensor is a color camera.

19. The illumination system of claim 3 wherein said separation unit for separating red (R), yellow (Y) and green (G) components of said collimated light beam is provided as an RYG dichroic X-cube splitter, said X-cube splitter producing two deviated side emerging channel beams, further comprising two tilted mirrors that deviate said side emerging channel beams to provide two light beams parallel to said collimated light beam, and an X-cube combiner.

20. The illumination system of claim 3 wherein said separation unit for separating red, yellow, and green components of said collimated light beam is provided as a series of tilted beam splitters.

21. The illumination system of claim 3 wherein the lamp source is composed of a multiple smaller light sources.

22. Claim 7 wherein the color segments of the filter wheel are not equally big yielding different exposure and frame times for each color in order to compensate for the selective color transmittance of the sclera.

23. The illumination system of claim 7 wherein said filter wheel is comprised of four filter sections, with sections for red, yellow, and green being substantially equal in size and said red, yellow, and green sections being larger than a transparent section.

24. The illumination system of claim 3 further comprising a second filter wheel for use in at least one of monochromatic illumination and excitation with angiographic agents.

25. The illumination system of claim 24 wherein said second filter wheel further comprises a transparent section to allow full spectral content of said collimated light beam to pass through said second filter wheel.

26. The illumination system of claim 7 wherein said filter wheel is comprised of four filter sections, with sections for red, yellow, and green being substantially equal in size and said red, yellow, and green sections being larger than a blue section of wavelength range adequate for excitation of angiographic agents.

Ref r nces Cited [R ferenced by]

U.S. Patent Documents

3954329	May, 1976	Pomerantzeff
5966196	Oct., 1999	Svetliza, et al.
6309070	Oct., 2001	Svetliza, et al.
60/451272 (provisional)	Apr. 2003	Gil, et al.
4061423	Dec., 1977	Pomerantzeff
4200362	Apr., 1980	Pomerantzeff

Other references

Carol L. Shields, MD, Miguel Materin, MD, John Epstein, MD, Jerry A. Shields, MD, *Wide-angle Imaging Of the Ocular Fundus*, Review of Ophthalmology, Vol. 10:02, 2003.

Description

Field of the invention

This invention relates to ophthalmoscopes, fundus cameras, slit lamps, and operation microscopes, i.e., instruments for viewing and imaging the interior of the human eye. More particularly, the invention provides an illumination method, serving to provide adequate illumination for the diagnostic and documentation purposes of these systems, while making their operation possible without pupil dilation, enlarging their observable field to the whole fundus, and by-passing illumination difficulties due opacities and scattering of the anterior chamber of the eye. Observable field is the area of the fundus beyond which the observation system is unable to reach.

Background of the invention

Currently, most of the fundus-viewing and imaging systems illuminate the interior of the eye through the pupil of the eye by a light source that is located in the region of the camera and is directed into the posterior segment of the eye. These systems suffer from reflections of the illuminating light off the cornea, crystalline lens, and its interface with the vitreous cavity. They need typically more than half of the pupil area for illumination, and when

attempting to view the interior of the eye more peripheral than the macula, the effective pupil size that is available becomes smaller and light does not go through. As a result, standard fundus viewing and imaging systems depend strongly on clear ocular media and on wide pupil dilation, and they are limited to a maximum of 60° field of view (FOV) and cannot observe the periphery much beyond the posterior pole. They are thus limited in patients with nondilating pupils such as those with chronic glaucoma, uveitis, and diabetes mellitus, and in patients with opaque media, cataract, and pseudophakic lens.

The problems evolved in illumination the interior of the eye through the pupil can be avoided when the interior of the eye is illuminated through the sclera (transcleral illumination), as first proposed by Pomerantzeff in US patent 3954329. This method supports wide angle fundus imaging without demanding pupil dilation and by-passing illumination difficulties that may rise due to obstruction and scattering from opacities in the anterior eye chamber. In addition it enlarges the observable field to the whole fundus. Recently a system (Panoret-1000™ of Medibell Medical Vision Technologies, Ltd.) that is based on US patents 5966196 (Svetliza, et al.) and 6309070 (Svetliza, et al.) has applied transcleral illumination according to US patent 3954329. The advantages and applicability of transcleral illumination as realized with Panoret-1000™ have recently been discussed by Shields et al. (Rev. Ophth. 10, 2003).

An important factor that needs to be taken into account upon transcleral illumination of the interior of the eye are the optical properties of the tissue that the light goes through upon entering the eye. Before reaching the eye cavity, the light crosses the conjunctiva, the sclera, the choroid, the retinal pigment epithelium and the peripheral retina. These layers act as a red filter of light in the visual range, transmitting a maximum of 50% of red light and 10% of blue light. As a result, within eye safety limits, the amount of blue light that reaches the interior of the eye compromises very much the ability to obtain color images that would be based on red (R) green (G) and blue (B) contribution, so-called, RGB images. In fact, analysis of fundus color images that have been obtained by shining the sclera through red, green, and blue filters showed that the color images contained only red and green components, while the blue signal detected by the camera was weak and without features. Moreover, in very dark eyes even the green illumination

component may be too weak to contribute information to the color image.

The fact that the blue component (nor the green component in very dark eyes) of the illuminating light does not reach the interior of the eye implies that the eye is exposed unnecessarily to light that does not contribute to the resulting image, and that some of the retinal findings that would be visible in three-components color images are now hidden. Moreover, the signal to noise ratio (SNR) that could theoretically be reached in similar acquisition time but with light that would have entered the interior of the eye is thus such reduced.

Accordingly, the object of this invention is to provide a method and a system for obtaining high-spectral and high-spatial resolution color images of the interior of the eye by applying transcleral illumination. This is achieved by shifting the lower limit of the illumination spectrum to wavelength values that are transmitted by the sclera, yet dividing the spectrum into three ranges in order to enhance both the SNR and spectral resolution. More specifically, we illuminate the eye by consequent red, yellow, and green beams instead of red, green, and blue, respectively.

Brief description of the drawings

For a better understanding of the invention with regard to the embodiments thereof, reference is made to the accompanying drawings, in which like numerals designate corresponding elements or sections throughout, and in which:

FIG. 1 is a preferred embodiment of the illumination system of the present invention;

FIG. 2 is the RYGT filter wheel;

FIG. 3 is an alternative embodiment of the illumination system of the present invention;

FIG. 4 is a further alternative embodiment of the illumination system of the present invention; and

FIG. 5 is a block diagram of the computerized controls of the illumination system of the present invention.

Summary of the invention

The principal object of the present invention is_to overcome the difficulty of illuminating the interior of the eye through the sclera with white light that would be strong enough to enable the acquisition of clear and high-resolution color images without compromising eye safety. Instead of illuminating the sclera with red, green, and blue (RGB) light beams that would typically be used to compose a color image (US patent 6309070, Svetliza, et al.), we illuminate it with red, yellow, and green (RYG) light beams, taking advantage of the fact the sclera transmits yellow light twice as much blue and of the fact that the yellow light is much less hazardous to eye tissues. Moreover, alignment and focusing as preparation for the color acquisition is done under yellow light alone, which is the longest wavelength and least hazardous light component that still images the retina and not the choroid. Color images of the interior of the eye are then obtained by taking the R-, Y-, and G- corresponding grey- level-coded images of the fundus and treating them as red-green-blue (RGB) images by a post processing unit, which combines them to give a color image. Specifically, the red component of the color image is given by the red-illuminated image required, the green component by the yellow-illuminated image, and the blue component by the green-illuminated image.

Given this invention, transcleral illumination with its aforementioned advantages will yield images with higher than heretofore spectral and spatial resolution and signal-to-noise ratio (SNR). In addition it will be applicable also for that portion of dark-pigmented patients whose sclera does not transmit the blue and green light.

In accordance with a preferred embodiment of the present invention there is provided a method for integrated ophthalmic illumination comprising the steps of:

1. providing a light source producing a light beam;
2. separating red, yellow, and green components of said light beam;
3. sequentially illuminating the eye with said separated red, yellow, and green components at a rate of one component per frame;
4. imaging said sequentially illuminated subject;
5. processing said sequential color images such that said separated red, yellow, and green components are combined

as red, green, and blue (RGB) components so as to obtain a high resolution color image.

There is also provided an integrated ophthalmic illumination system comprising:

1. a light source, said light source being a lamp;
2. collimating optics, to provide a collimated light beam from said light source;
3. a separation unit for separating red, yellow, and green components of said collimated light beam, so as to produce sequential color images;
4. a computer processor; and
5. an electronic image capturing sensor, said computer processor taking said sequential color images obtained and forming therefrom at least one of a high resolution color and monochromatic image.

In the preferred embodiment of the invention, there is provided an illumination system having a lamp (including but not limited to a tungsten, metal halide or halogen lamp or any type of filament, gas, laser, or semi-conductor diode lamp). In a preferred embodiment, color images are provided using a red-yellow-green-transparent (RYGT) filter wheel. The filter wheel is divided into four sections or arc sections around the periphery of the wheel. Three of the four partitioned sections are larger and equal sections that comprise the three optical R, Y, and G filter sections. The fourth section is a transparent, or empty, narrow section that is used for transferring the full original content of the white beam when a monochromatic or chromatic image is desired, e.g., in order to emit fluorescence exciting light beam. Alternatively, this narrow section can be made the filter that provides the fluorescence exciting beam.

In order to produce color images, the RYGT wheel rotates at a speed of one third of the frame rate of a CCD camera, producing a sequence of definite R, Y and G spectral light bursts. These light bursts illuminate the interior of the eye, enabling a whole image of the eye fundus to be reflected out and detected by the image capturing sensor. These R, Y, and G illuminated images are later composed by a computer into a single colored picture.

In order to produce monochromatic images, the RYGT wheel stays in a fixed position at which the light passes through the transparent (T) section, or, alternatively through this section when it serves as a filter, producing a fluorescence exciting beam.

In order to enable focus and alignment under near-infra-red (NIR) illumination, thus avoiding pupil contraction before color image acquisition, two alternative embodiments are presented. One includes a high-pass filter to transmit near-infra-red (NIR) from the light source. The other one comprises a low-pass filter that in synchronization with a high-pass red segment of the RYG filter wheel yields a band-pass near-infra-red (NIR) illumination. Switching to acquisition of a color image after performing NIR focus and alignment is supported by a mechanism of fast exchanging the low-pass with the hot mirror band-pass filter.

In an alternative embodiment, similar color splitting is accomplished by means of an X-cube splitter used to divide the white light into its R, Y and G components. In yet another preferred embodiment, a series of three 45° tilted beam splitters or dichroic spectral beam splitters are used to divide the light into three channels, and then the desired wavelengths are filtered from each channel.

Other features and advantages of the invention will become apparent from the following drawings and description.

Description of illustrated embodiment

Without losing generality, we provide here an exemplary realization of the presented invention by **adding** to the existing illumination system of Panoret-1000™ (Medibell Medical Vision Technologies, Ltd.), which is built in accordance with US patent 6309070 (Svetliza, et al.).

Referring to FIG. 1, there is shown illumination system 10, in which a lamp 12 (by way of example a tungsten, halogen or metal-halide lamp or any type of filament or gas lamp) produces a well defined collimated light beam, with the aid of matching beam-expander optics 14. Hot mirror 16 is placed in the optical path close to the light source to remove ultraviolet (UV) and infrared (IR) components of the light spectral content. Electro-optical fast shutter 18 (by way of example, LCP250 scattering liquid crystal polymer shutter, by Philips, the Netherlands) controls the amount of light in the collimated beam that traverses through the shutter. It does it by changing the shutter light scattering effectiveness (i.e. its direct

transmissivity). Neutral density filter 20 may be inserted to enable a more pronounced light power change in the traversing beam. Additional correction optics, e.g. 22, may also be placed downstream of the optical path for beam correction and shaping.

Photodiode 24 monitors the overall light intensity within the optical beam, by means of beam splitter 25 which is introduced into the collimated beam reflecting a small fraction of the main beam light to photodiode 24. This mode of light measurement provides an important safety feature when used with sensitive tissue, such as in the eye.

Towards the end of the light path the collimated beam is focused onto entrance aperture 26 of a fiber optics feeding cable using a short focusing aspheric condensing lens 28. A short focus lens is recommended in order to minimize the beam spot-size dimensions on the entrance aperture plane of the fiber optics bundle guide. Light power of the order of several hundred milliwatts can easily be focused on the output end of the fiber optics feeding bundle.

The filters of rotary wheel 36 may be positioned in the optical path for monochromatic illumination. Rotary filter wheel 36 has several spaced filters mounted around a disc. Wheel 36 locks in certain positions where one of the interchangeable filters overlaps the entire beam cross section, thus isolating a certain spectral window from the fill "white" content of the beam. This enables a specified spectral band or colored illumination to illuminate the subject. The monochromatic filters of the rotary wheel may be used also as excitation filters for fluorescein angiography purposes. By way of example, the filter wheel is provided with narrow band-pass optical filters and a transparent (T) or empty window. When filter wheel 36 is locked in position so that the transparent or empty window overlaps the beam cross section, the full power and spectral content of the light beam is allowed for transfer to the next station.

In order to enable color imaging without any loss of the high resolution available from a black and white CCD camera, a second RYGT filter wheel 38 is used in the optical path. As shown in FIG. 2, this wheel is divided, by way of example, into 4 partitioned section, the R, Y and G sections being larger and equal and a fourth section, the T section which is used for transferring the full original content of the white beam. The dimensions of the T section, at a minimum, overlap the cross-section of fiber optic cable aperture 26. In an

alternative embodiment instead of the transparent (T) section, we place a narrow-band filter of a wavelength range that is appropriate for exciting a fluorescein dye for angiographic applications.

In order to establish the highest achievable duty cycle for each of the three main R, Y and G colored sections, RYGT wheel 38 is preferably positioned close to a plane where the beam is narrowed to a minimum (i.e. near the focal plane of fiber optics outlet port aperture 26). With wheel 38 thus positioned, the projection of the beam cross-section is small, meaning that the T section of the wheel can be at its smallest possible size while still covering aperture 26. This allows the largest duty cycle for the three remaining optically filtered sections, RYG. When RYGT wheel 38 rotates at a speed of one third of the frame rate of the CCD camera, a sequence of definite R, Y and G (with a short white) spectral light bursts are transferred to aperture 26 per each revolution of RYGT wheel 38. Each of these R, Y or G sequenced light bursts is fully synchronized with one of the consecutive frames of the CCD camera located in the detection channel. This produces R, Y and G illuminated images in sequence, each frame of the camera having one color. These images are later composed by the computer into a single colored picture. Thus, every three consecutive monochromatic "colored" images comprise one colored picture. The computer updates these colored pictures at the rate of the camera frame rate, each time a new "colored" frame is detected.

Referring again to FIG. 1, when color pictures are no longer required, RYGT wheel 38 is locked in a position where the T section overlaps the beam cross-section, allowing the full impinging light content from lamp 12 to be passed to aperture 26. When locked in this "white" position, the light can be used for angiography or for specific monochromatic illumination purposes by introducing the appropriate filters into the optical path using filter wheel 36.

As shown in FIG. 3, in an alternative embodiment of illumination system 10, a similar light path is constructed in which a halogen or metal-halide lamp 12 produces a well-defined collimated light beam, with the aid of matching beam-expander optics 14. Hot mirror 16 is placed in the optical path close to the light source to remove ultraviolet (UV) and infrared (IR) components of the light spectral content. In this embodiment, the main beam is split into three "colored" channels (R, Y, G) using R-Y-G dichroic "X-cube" splitter

40 with two 45.degree. tilted mirrors 42 that deviate the side emerging channel beams to produce three parallel beams. To overcome a possible loss of some polarized light beam components due to polarization sensitivity of X-cube splitter 40, polarization converter prism 44 is inserted in the light path preceding X-cube splitter 40, so as to transform the impinging randomly polarized light beam into a linearly polarized one.

Three electro-optical fast shutters 46 (by way of example, LCP250 scattering liquid crystal polymer shutter, by Philips, the Netherlands) are placed in each of the three split channels to switch on the channels sequentially, each for a duration of one camera frame. Beside the act of switching, shutters 46 are also used for controlling the beam power in each of the channels in order to correctly balance the light power relationship between the three channels.

The three separated channels may be recombined into a single beam by X-cube combiner 48, with the aid of two 45° tilted mirrors 50. When the three (RYG) shutters are operated sequentially, one per each camera frame duration, Red, yellow, and green light bursts sequentially emerge from X-cube combiner 48. Focusing lens 28 is used to focus the emerged collimated beam onto aperture 26. When colored pictures are not required, all of fast shutters 46 are kept locked in their transparent mode. The combined R, Y and G beams constitute a white light beam together that is passed to aperture 26. As in FIG. 1, the white beam illumination can be used for angiography or for specific monochromatic illumination by introducing the appropriate filter into filter wheel 36.

Referring now to FIG. 4, another alternative embodiment of illumination system 10 is shown in which the splitting of the main channel into R, Y and G sequential synchronized light bursts is accomplished using a series of three 45°-tilted beam splitters: 30R/70T beam splitter 52, 50R/50T beam splitter 54 and 45°-tilted mirror 56, and adding an R, Y or G optical filter to each of the channels. Alternatively, a series of three 45°-tilted dichroic spectral beam splitters in R, Y and G may be used (e.g. J43-454, J43-455 and J43-458 corrector, Edmund Scientific, Barrington, N.J., USA, respectively).

The use of three 45°-tilted beam splitters is the least efficient method of color splitting, as compared to the embodiments shown in FIG. 1 and FIG. 3, due to the partitioning of the total beam power

into three separated channels with about one third of the total power content in each channel. Therefore, the optical filters in each channel are separating out only part of the spectral content of the already reduced light power in the channel. Once the color splitting has been accomplished, mirrors 44 and X-cube combiner 48 function as described in FIG. 3.

Referring now to FIG. 5, there is shown a block diagram of the computerized controls of illumination system 10, provided as a printed circuit board (PCB) designed to control and monitor the optical parts of illumination system 10 (in any of the embodiments depicted in FIGS. 1, 3 or 4), and interface with host PC 60.

In block 62, the copper to fiber interface between the PC 60 and the illumination system is provided as a fiber optic interface for signal conversion, with communication of up to 100 Mbit/sec, bidirectionally. In block 64, the main processing unit (MPU), which may be, for example an Altera-based type, is in charge of communication with all I/O's and host PC 60. The control algorithms are implemented here.

In block 66 there is an option to camera optics control. A circuit in block 70 controls lamp 12. This may also be used as an emergency off circuit. Neutral density filter 20 is inserted or removed by block 72 to control light passing therethrough from light source 12. In block 74, there is provided a circuit capable of controlling up to three fast shutters such as 18 or 46, for continuous control frame resolution and color weighing.

The filter wheel control is provided in block 76 and drives rotary filter wheel 36. An 8 channel 10 bit serial analog to digital converter (ADC) is provided in block 78 for measuring light passing through the light source and for monitoring safe light levels in the light measuring circuit. Block 80 is a circuit used to revolve color wheel 38 so it is synchronized to the camera frame integration in color mode, and to position the wheel in its transparent sector in monochromatic and angiography test modes.

Clearly, the present invention may interface with the illumination path of a slit lamp, any kind of opththalmoscope, ophthalmic camera, surgical microscope, endoscope, culposcope, laparascope, or other medical device. In this way these devices become versatile, allowing a wide range of test capability with a single optical system which includes color, monochromatic and angiography imaging ability.

Having described the invention with regard to certain specific embodiments thereof, it is to be understood that the description is not meant as a limitation, since further modifications may now suggest themselves to those skilled in the art, and it is intended to cover such modifications as fall within the scope of the appended claims.

Figures

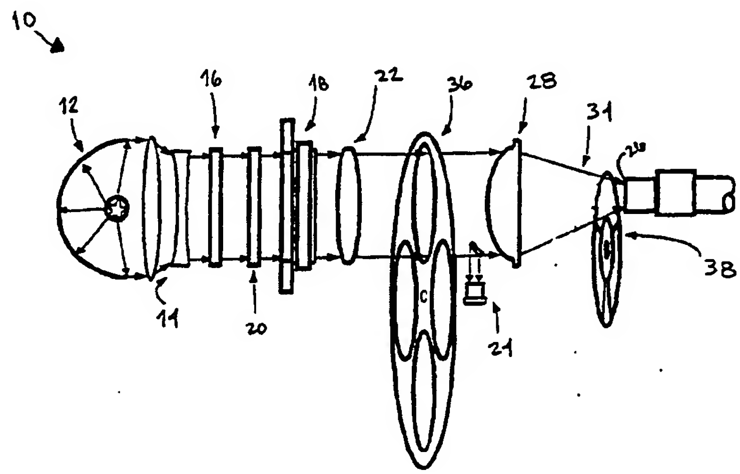
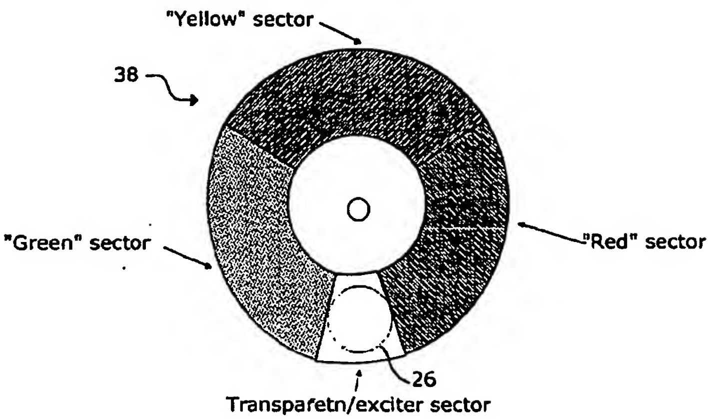


Fig. 1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38
"Green" sector
"Red" sector
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Transparetn/exciter sector

Fig. 2

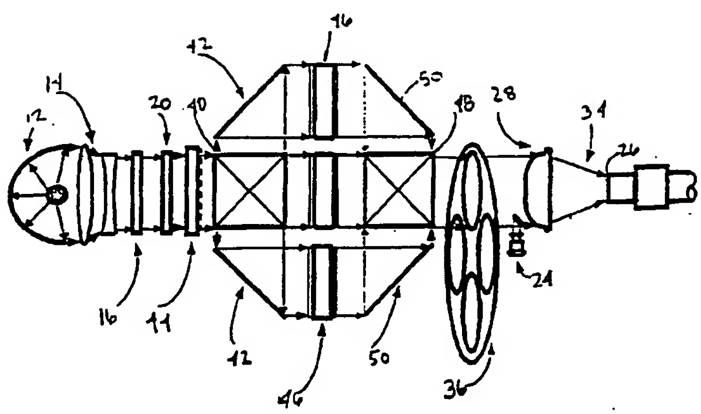

Fig. 3

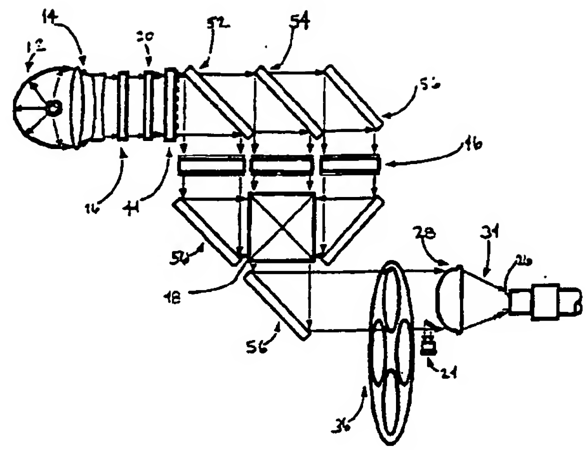
14
54
48
56
28
34
36

Fig. 4

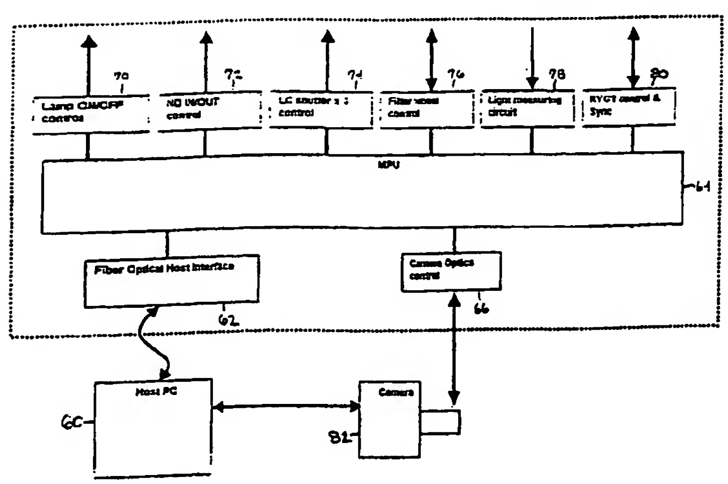
70
72
74
76
78
80
Lamp ON/OFF control
ND IN/OUT control
Light measuring circuit
MPU
64
Fiber Optical Host Interface
62
Camera Optics control
66
Host PC
Camera
82

Fig. 5

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